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# Key Performance Indicators for Field Service

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Electrical Engineering

Thesis

June 5th, 2013

Author Title	Janne Ventola Key Performance Indicators for Field Service
Number of Pages Date	19 pages + 2 appendices June 5 <sup>th</sup> , 2013
Degree	Bachelor of Engineering
Degree Programme	Electrical Engineering
Specialisation option	Electronics
Instructor(s)	Juha Alamäki, Project Manager Eero Kupila, Senior Lecturer
<p>The purpose of this study was to design metrics to measure the effectiveness of field service in the ABB Finland's Drives Service division.</p> <p>The need for this graduate study arises from lack of utilization of field service reports that are stored in ABB's drives database called Drives Installed Base (DIB). The data stored in the Drives Installed Base can be used to devise metrics called Key Performance Indicators to track and improve field service maintenance efficiency. The principal stakeholder for this study is the ABB Finland Drives Service.</p> <p>In order to come up with a functioning system a continuous process to improve maintenance quality was devised along with the KPIs needed for its implementation.</p> <p>The scope of this study is limited to the proposal of the KPIs and therefore does not include in any way what platform or software is used in their implementation.</p> <p>The proposed KPIs provide a targeted approach into analysing maintenance performance in a way that is specific and quantifiable. This provides the basis for future development.</p>	
Keywords	Drives Installed Base, Business Unit, Key Performance Indicator, Mean Time Between Failures, Field Service, Maintenance, variable-frequency drive

## Preface

I would like to begin by offering my thanks to the highly professional people of ABB who made this graduate study possible. In particular I would like to name Juha Alamaäki, my instructor from ABB, who was always ready to make time from his busy schedule and help me set up meetings and move towards the right direction. I would also like to extend my thanks to my very helpful graduate study advisor from Metropolia, Eero Kupila for helping me with all the details and making me feel comfortable about the progression of my graduate study.

## Abbreviations/acronyms

DIB	Drives Installed Base
BU	Business unit
KPI	Key Performance Indicator
SQL	Structured Query Language

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## 1 Introduction

This study was contracted by the ABB Finland's Service division. Drives Service is responsible for customer relations, product information and product management concerning the variable-frequency drives manufactured in Finland. This includes all drives deployed around the world. The division provides service to the customers all throughout the lifecycle of the equipment. In short, Drives Service is responsible for the after sales maintenance of the equipment. The top-level Drives Service organization structure is shown in appendix 1.

In any kind of Service operation, maintaining quality is an integral part in achieving customer satisfaction as well as improving product quality. Tracking the performance of the maintenance operation provides insight into what specific qualities are most vital in maintaining an improving trend. The ABB's platform for storing the data required to track performance is the Drives Installed Base (DIB). It is a database that contains all relevant information about the devices in the field, like maintenance reports and equipment details. In the scope of this study, the relevant information is the reports that are entered into the database by the field service engineers. These reports contain information about all the maintenance work the engineers perform in the field. The data in the reports need to be as detailed and complete as possible to make an analysis accurate.

The concept of key performance indicators (KPIs) becomes relevant when considering how to measure the performance of the maintenance operation. KPIs are a set of metrics that can be used to measure performance in terms of the organization's stated goals. To be able to track an organization's success over time, employing a set of KPIs is not enough. It is important to have a framework of processes to create a self-sustaining 'loop' that upholds the quality of operations.

Existing analysis on the data in the Drives Installed Base concentrates on creating graphs and figures from a multi-layered collection of parameters and variables. This approach is too convoluted to be used when trying to track the maintenance operation's success on a high level. Currently, there is no functional, on-point analysis performed on the data that is available in the field Drives Installed Base. In the scope of

this study is to propose a set of KPIs to measure maintenance performance and propose basics for a process of continuous improvement for the maintenance operation.

Firstly, the process required to maintain the continuous improvement was outlined. Secondly the KPIs required to track each function of the process and further useful metrics outside of the KPIs were proposed. After all the relevant processes and metrics were introduced, the adjustments needed to implement the KPIs were explained.

## 2 Background

### 2.1 Field Service Data Flow

The information flow can be seen in figure 1. A field service report is stored into Drives Installed Base. From there the data is stored into an SQL database and eCoach generates KPI driven content for the end functions to utilize. For more information regarding SQL and eCoach, see chapter 2.3.

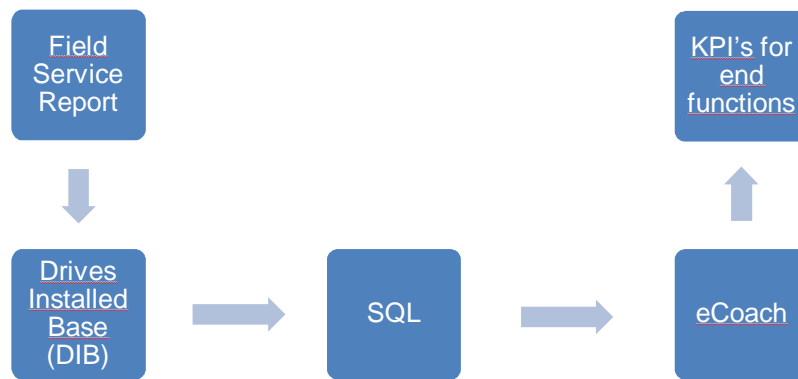


Figure 1: Field Service data flow

### 2.2 Field Service Report and Drives Installed Base

The Drives Installed Base is a database used to track equipment at customer sites. The database contains all documentation regarding the installed drive and its components, and the different types of maintenance reports performed on the drive.

A new version of this site is currently under construction and set to be released during the summer of 2013. New features include alerts for bookmarked drives that inform you



if they have had repeated service events in a short time span, making it possible to detect problems faster. Changes in lifecycle are also reported.

The field service report comes in the form of Windows InfoPath template. There are different templates for different types of maintenance work. In the scope of this study, the relevant report type is “on-site repair” or “field service report”. The content of the reports consists of a variety of different fields for failures, exchanged components, free-text descriptions and status information regarding the equipment.

### 2.3 SQL Database and eCoach

Predisys eCoach (1) is a computer software for managing and monitoring production data. It can be used to collect and analyze data to produce the Key Performance Indicators defined in chapter 4. It uses Microsoft Office system as a platform, and is therefore capable of interacting with Microsoft SQL database. Here, it is used in conjunction with the SQL and Microsoft Infopath to produce results.

Structured Query Language (2) is a database management system (DBMS) used in defining, querying, updating and administrating databases. It allows the user to interact with the database in a practical manner.

The data in the Drives Installed Base is stored in a Microsoft SQL format, which is compatible with eCoach. In conjunction, they provide necessary interface to produce the KPIs.

## 2.4 KPIs

Bernard Marr (3) defines Key Performance Indicators as “measures that provide managers with the most important performance information to enable them or their stakeholders to understand the performance level of the organisation.”

Simply put, KPIs are metrics designed to track and measure the organization's success over time. A Key Performance Indicator is always tied to a target.

The KPI metrics vary between companies and industries. Service industry might look more to KPI's like Mean Time to Repair (MTTR), Mean Time to Failure (MTTF), fix rates and field service engineer utilization like Average Time to Respond (ATR).

It is important that the selected KPIs are specific and quantifiable. The KPIs cannot be subjective. For example, if a field engineer's response time is to be improved, it is required that there is an exact definition in terms of time what is above or below the desired response time. This means that there needs to be a reference level for each KPI to be able to track success over time.

The number of KPIs should be kept to a minimal. The more KPIs you have, the more likely it becomes that they will be in conflict with each other. For example, a KPI that measures revenues may be in conflict with a KPI that measures profitability. Ultimately, it is up to the senior management to decide which measurement is most important.

In addition to the fact that KPIs can be used to improve the industry sectors performance, they can also be used as promoting tools in different publications.

### 3 Continuous Improvement

Continuous Improvement is a process designed to manage the maintenance process of a large organization. It is a 'framework' that is a conceptual structure that can be used to address issues, such as a project. It includes a set of assumptions, project-specific metrics, concepts, values and processes that provide the stakeholder means of viewing what is needed to improve customer satisfaction. A framework is a skeletal support for building the project's desirables (4 pp. 17).

Here, continuous improvement process was designed to provide a framework to utilize the KPIs in an organized fashion. Ultimately, its goal is to track and improve the performance of the maintenance function as a whole.

The purpose here is not to come up with an exact implementation of these processes, but to provide a foundation for future development.

The process is represented in figure 2.

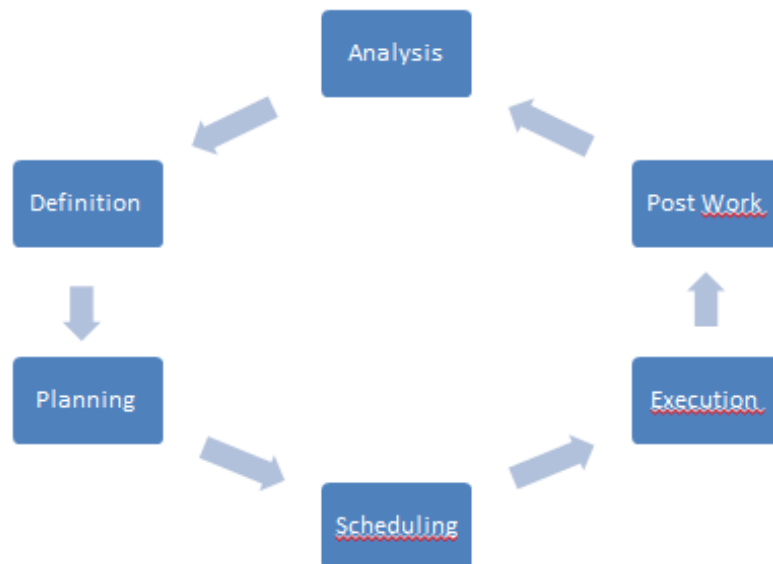


Figure 2: Continuous Improvement

The process depicted here is solely designed for the maintenance function. This process would ultimately require a higher level process of its own designed from the business point of view that is not explored here. For example, these would be KPIs relating to administration and personnel management.

The basic purpose of this process is to produce results. Results in this context mean the procurement of the KPIs to be able to track the success of the maintenance operation as well as coming up with strategies to improve said performance.

The purpose of the maintenance process is to improve reliability and customer satisfaction. Continuous improvement requires a collection of tasks to create the total maintenance process. All steps need to be implemented to be able to uphold the total maintenance function. This study focuses on the maintenance process and proposes a set of KPIs for its implementation. What follows is a brief description of each step in the process.

**Definition** is the starting point of the loop. Here, the work orders are processed after the customer has submitted them. When the process begins, the description in the submitted work request is used to assess the impact of failure modes of the equipment and rates them accordingly. The rating reflects on the equipment's ability to perform its desired function and the failure's probability. The point is to ascertain whether it is worth it to perform the activity. Identifying work worth doing has a high impact on the cost of maintenance; resources are easily wasted. This kind of work can be called proactive work. Part of the definition process is defining what work needs to be done in order to avoid potential failures.

**Planning** stage identifies the resources and instructions for the required maintenance work. Efficient planning means that the work at the customer site is as expedient as possible.

There is always a required time frame for any particular maintenance work. **Scheduling** identifies the time frame for the activity, and evaluates the costs relating to the equipment downtime caused by the activity. **Execution** process is simply the act of executing the planned activities.

The **Post Work** process utilizes the information documented in the execution process. It logs all the relevant information, such as the time it took to complete the work, requested follow-up procedures and corrective work requests. Also the documentation regarding the equipment in the Drives Installed Base will be updated to reflect the changes.

**Analysis** is where the gathered data and current trends are reviewed. In practical terms, the effectiveness of the maintenance operation is evaluated. During this process the results of past actions can be seen as well as future actions are devised.

Analysis is the only process that does not have a KPI to measure.

## 4 Defining the Key Performance Indicators

The measured Key Performance Indicators can be divided into two categories: leading KPIs and lagging KPIs (4 pp. 112). Leading indicators are typically input oriented, whereas lagging KPIs are output oriented. For example, when a person is trying to lose weight, the leading indicators would be calorie intake and calories burned. The lagging indicators in this case would be the actual weight loss observed.

Definition, planning and scheduling can be characterized as having leading KPIs, whereas execution, Post Work and analysis can be characterized as having lagging KPIs. The difference within the context of this paper is that the data for the leading KPIs are not available from the field service reports or the SQL database.

The desired target level for the KPIs should be decided when the current reference levels have been established. The current reference levels can be established when the data has been extracted from the SQL database using eCoach. The measuring periods can also be adjusted afterwards to a level deemed suitable for ABB's needs.

### 4.1 Definition KPIs

Work definition begins when a work request has been submitted by the customer. Definition KPIs can be divided into two categories. One that reflects the on-time success of requested work procedures by the customer and one that reflects proactive maintenance work. The former measures the effectiveness of the work request handling procedure and the latter indicates how much effort is placed on proactive maintenance work.

#### 4.1.1 Work Request

When a customer submits a request for maintenance work, it has to be reviewed and approved before it becomes an actual task to be performed. It is one way of identifying work. The request procedure is working well when work requests are handled fast enough.

The key performance indicator for work initiation is the percentage of work orders in 'pending' status for less than 5 days.

#### 4.1.2 Proactive

Defining what work needs to be done is mainly proactive in nature. The key in maintenance success is identifying potential failure conditions and acting before they occur. For this to be possible, proactive maintenance work needs to be separated from reactive work. This would be done by flagging the data in the reports accordingly.

Proactive work includes, for example, identifying potential age or environmental conditions that are likely to cause failures.

The term 'proactive maintenance' is used here to avoid confusion with 'Preventive Maintenance' that ABB uses for its general maintenance kits. Preventive Maintenance kits are proactive in nature, but do not include all work that is proactive.

If the defined work is working properly, the majority of work orders will fall under the proactive work category.

The key performance indicator for proactive work is

$$\frac{\text{Proactive working hours}}{\text{Total working hours}}.$$

## 4.2 Planning KPI

An important part of the maintenance process is that the work is well planned. The maintenance plan contains details about the resources that are needed to perform the work as well as labour timing.

The purpose of the plan is that the maintenance work performed at the site is as comprehensive and expedient as possible. This part of the continuous improvement measures the effectiveness of the plan.

The first key performance indicator is aimed at measuring working time accuracy estimates. It is defined as the percentage of work done within 10% of the estimate.

The second key performance indicator is aimed at measuring the accuracy of material requirement estimates. It is defined as the percentage of work orders delayed by inadequate materials.

## 4.3 Scheduling KPI

The Scheduling function should combine the requirements of the assets and the resources that are needed to perform the maintenance into creating a schedule to be followed. By analysing this information, a schedule for the maintenance is created that includes a “completed-by” date. The KPI for scheduling indicates how many work orders have been scheduled in time.

The Key Performance Indicator for Scheduling is

$$\frac{\text{Work orders scheduled before set date}}{\text{All work orders}}.$$

The aspect of scheduling work is separate from actual work done. Scheduling is a part of planning the maintenance work beforehand, thus it is outside the scope of available data from what is in the field reports submitted to the Drives Installed Base.



#### 4.4 Execution KPI

It is important to measure the completeness of the submitted reports. Because it does not always make sense to fill every field in the report, it is proposed that certain fields are marked as 'required' to fill. However, in order to for this metric to be relevant, it is proposed that as few fields as possible are left out.

The key performance indicator for this is

$$\frac{\text{completely filled reports}}{\text{total reports}}$$

Another metric for Execution is the percentage of work orders that are actually completed in time. This can be characterized as Average Time to Respond. The KPI for this is

$$\frac{\text{Work orders completed in time}}{\text{Total work orders}}$$

From a business point of view, it is important to track how many faults occur during the warranty period. The KPI for this is

$$\frac{\text{Work orders completed during warranty period}}{\text{Total Work orders}}$$

#### 4.5 Post Work

Among other things, Post Work includes all the follow-up requests relating to the work done. It is ideal that the required maintenance is successfully completed during the original work order, but sometimes follow-up procedures are requested by the client. If

a work order needs to be revisited after the fact, it usually something has been overlooked during the original maintenance.

Part of measuring the success of executing the work is how large percentage of the work orders needs to be revisited after the maintenance work has been performed in a given time period. The Key Performance Indicator for this is

$$\frac{\text{Work requests revisited}}{\text{Total work requests}}$$

#### 4.6 Key Performance Indicators outside of the Process Functions

Outside of the process specific KPIs, there are useful indicators that track the repeat failures of the equipment. It is also suggested that the severity and impact of the failures are tracked in a way that reflects a general trend over long period of time.

##### 4.6.1 MTBF

Mean Time Between Failures predicts the time that passes between system failures during operations. The ways of calculating MTBF vary from complicated to simple. In context of KPIs, it needs to be simple, high level calculation to meet the definition of a Key Performance Indicator.

The KPI for MTBF is

$$\frac{\sum(\text{start of downtime} - \text{start of uptime})}{\text{Total failures}}$$

The total MTBF is therefore the sum of all downtime due to failures divided by the total amount of failures. The target range for this is context specific due to the myriad of reasons that contribute to failures. These can be anything from environmental conditions to differences in equipment.

#### 4.6.2 Failure Effects

An important part of the maintenance process is identifying key failure modes and tracking them in way that yields general information about their frequency and severity.

In case of reactive maintenance to a failure on the field, it is proposed that the failure is ranked according to severity and impact. The ranking table proposed below is a generic table that can be adjusted for ABB's needs as needed.

1. No relevant effect on reliability or safety
2. Very minor effect, no damage, only results in a maintenance action (only noticed by discriminating customers)
3. Minor effect, low damage, (affects very little of the system, noticed by average customer)
4. Moderate effect, moderate damage, injuries possible (most customers are annoyed, mostly financial damage)
5. Critical effect (causes a loss of primary function; Loss of all safety Margins, 1 failure away from a catastrophe, severe damage, severe injuries, max 1 possible death )
6. Catastrophic effect (product becomes inoperative; the failure may result complete unsafe operation and possible multiple deaths)

It is recommended that the failures are tracked by the amount of equipment failures within a time period by failure rating. This provides information about the severity rating and frequency of each failure.

Tracking failure effects in this way does not provide direct data on the failures' causes, but it is useful in analysing the general maintenance quality over long periods of time as well as providing information about the effectiveness of the safety features.

#### 4.7 Summary of The KPIs

The summary of the Key Performance Indicators can be seen in table 1.

Type	Process	Key Performance Indicator
Leading	Definition	Proactive working hours/Total working hours
Leading	Definition	Percentage of work requests in 'pending' status for less than 5 days
Leading	Planning	Percentage of work done within 10% of the estimate
Leading	Planning	Percentage of work orders delayed by material deficiencies
Leading	Scheduling	Work orders scheduled before set date/All work orders
Lagging	Execution	Work orders completed in time/total work orders
Lagging	Execution	completely filled reports/total reports
Lagging	Execution	Work orders completed during warranty period/Total Work orders
Lagging	Post Work	Work requests revisited/Total work requests
Lagging	Other	Failure frequency by failure ranking
Lagging	Other	Mean Time Between Failures

**Table 1: Key Performance Indicators**

## **5 Adjustments Required for Implementation**

Future development will be necessary to implement the proposed changes. It will require both changes to the existing field service report template as well as future cooperation with different branches. In particular, the continuous improvement framework proposed here will require well managed interaction to guarantee improvement in maintenance performance over time.

### **5.1 Changes for Definition Process**

In order to be able to measure whether the work is proactive in nature, the data needs to be flagged in the field service report accordingly. This can be done by adding a 'check box' in the Infopath document for each procedure performed by the engineer.

### **5.2 Changes for Execution Process**

In the case of flagging the reports whether they are completely filled out or not is a challenge. The proposed way to do this is to define certain fields as 'required', since in many cases it is not purposeful to fill all the fields.

In case of the work orders completed in time, it is necessary to tie the time between when the maintenance has been performed to when the work request has been opened. This requires certain interconnectedness between the field service report and the original work request case. More research into ABB's process of handling work requests is required.

### **5.3 Changes for Post Work Process**

The KPI for revisited work requires that the performed maintenance can be tied to the original maintenance work it is related to. This can be done by assigning case numbers to the field service reports. When a case number has multiple field service reports, it is possible to extract the number of revisited work.

#### 5.4 Changes for MTBF and Failure Effects

In terms of evaluating overall level of performance over a period of time, the MTBF should be measuring the overall performance of the devices on a top level.

However, the reports can be collapsed to include several layers of reporting, from device specific reports, country specific reports and all the way down to component level reports using eCoach.

In case of measuring failure severity and frequency it is simply required that the field service report includes a drop down menu that the severity rankings.

## 6 Discussion and Conclusions

There was discussion on the possibility of measuring specific component repeat failures with KPIs (See appendix 2). However, the metrics for measuring something like this does not fall under the definition of KPI's because of the nature of the data. Measuring the failures of so many different possible components requires too many variables.

Even though it is not in the scope of this study to research the exact data needed to produce these results, it is possible to collect this data separately into its own data set using the data embedded in the Drives Installed Base. Component specific MTBFs can be calculated using the same methodology.

The next step is to implement these KPIs into the Drives Service structure of ABB. In an organization as large and interconnected as ABB, integrating these metrics into its existing maintenance structure will be its own project. Extracting component specific MTBFs into useful data might require someone with specific experience about reliability theory.

It is also necessary to extract the current reference levels of the KPIs. After this has been done, the current performance can be evaluated and steps can be taken to ensure an improving trend.

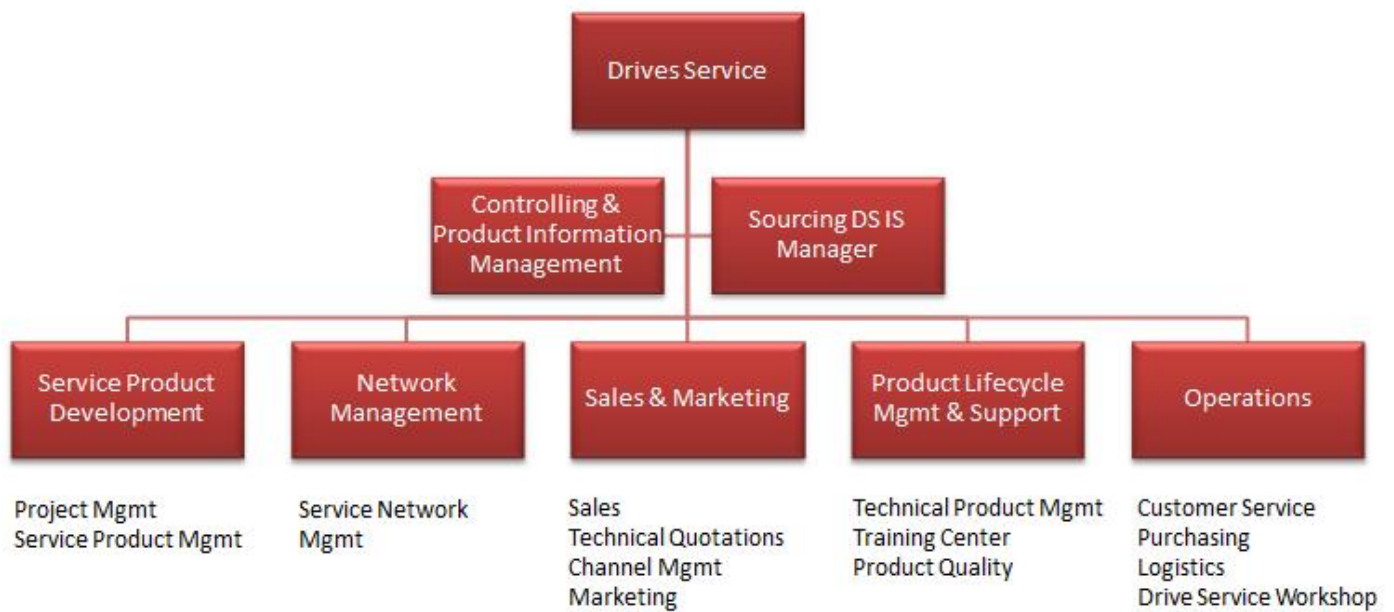
Also, further development might require adapting existing practices with the processes suggested here.

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## Drives Service Organization 1.1.2013



11.1.2013

Product Lifecycle Management Priorities, Participants (Timo Svensk, Pekka Rantanen, Janne Ventola)

- Fault percentage during warranty period
- Fault causes for individual devices; ie. which components fail and what are the circumstances
- Maintenance history and a record of procedures
- Information about decommissioned equipment (less importa

